# H2Only

## The Sediment Solution

## Design Review 11/17/2016


| Team Members | Instructor | Client | Sponsor |
| --- | --- | --- | --- |
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# Problem Statement

The floor of the University of Idaho's chilled water tower accumulates sediment as the water lies stagnant. The current method of removing the sediment is very expensive.


# Current Sediment Removal Process

Scuba diver inspection

2.5 million gallons drained

Sediment vacuumed out

Tank recharged

# Cost Estimates

| | Steam Plant Water Treatement (Conditioning / Softening / Amine) | Chilled Water Treatement (Conditioning / Softening / Biocide) | Domestic Water (Disinfection) | Inhibitor (Corrosion Inhibitor) | Reclaimed Water Treatment (Class B, Disinfection) | Recreational Water Treatement (Disinfection) | Total Water Treatment Costs |
|---|---|---|---|---|---|---|---|
| | | | | | | | |
| | | | | | | | |
| REX001 | $ 80,000.00 | | | | | | $ 80,000.00 |
| Chilled | | $ 95,000.00 | | $ 95,000.00 | | | $ 190,000.00 |
| REX020 | | | $ 11,000.00 | | | | $ 11,000.00 |
| REX025 | | | | | $ 28,000.00 | | $ 28,000.00 |
| RCX560 | | | | | | $ 10,000.00 | $ 10,000.00 |
| Total Water Treatment Costs | | | | | | | $ 319,000.00 |

# Cost of Chemical Lost

$$\frac{gal\ in\ tank}{gal\ in\ system} * chemical\ cost = \frac{Chem\ Cost}{Cycle}$$

$$\frac{Chem\ Cost}{Cycle} = \$176{,}382$$

# Chilled: Scuba and In House Labor Estimates

Scuba: $55,000

In house labor: $32,000

# Total Cost Per Cleaning Cycle Estimates

With Scuba - $231,382

In house - $208,382

# Our Goal

## An effective, efficient, less expensive system to clean tank

How?

Versatile design

Automatic operation

Sediment level detection

Permanently installed

Inexpensive construction

# Full Scale Specifications

Remove 95% of sediment each time system operates

Continue tank operation while cleaning

External sediment separation and recycle of clean water

Easy maintenance

Fully automated operation

Versatility for application in multiple tanks

# Prototype Specifications

Scalable to full scale dimensions

Avoid resuspension

Evenly distributed suction through slit

Demonstrate proof of concept

# How it Works (The Basics)

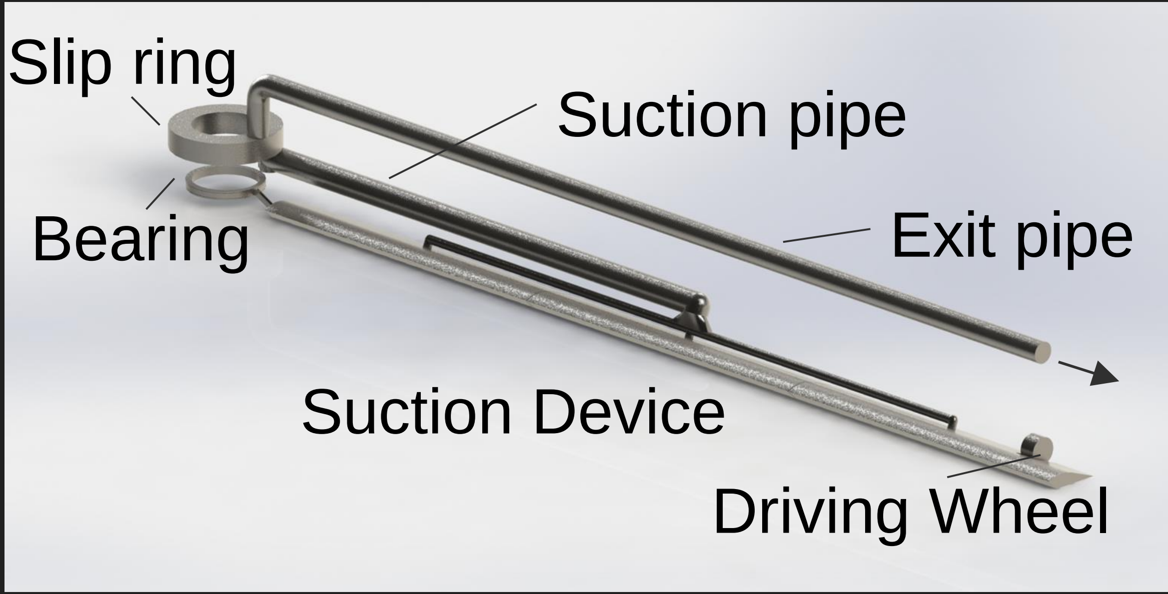
Suction

- Vertical head causes internal pressure due to gravity
- Pressure differential creates suction through device

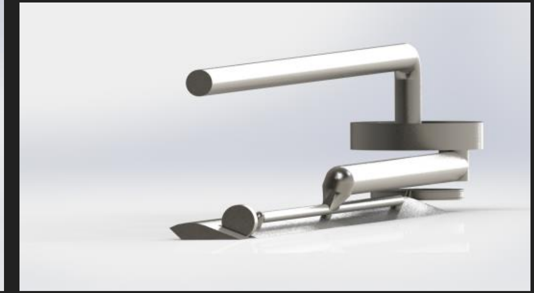
External Separation

- Centrifugal separator
- Recirculate clean water
- Dispose of sediment

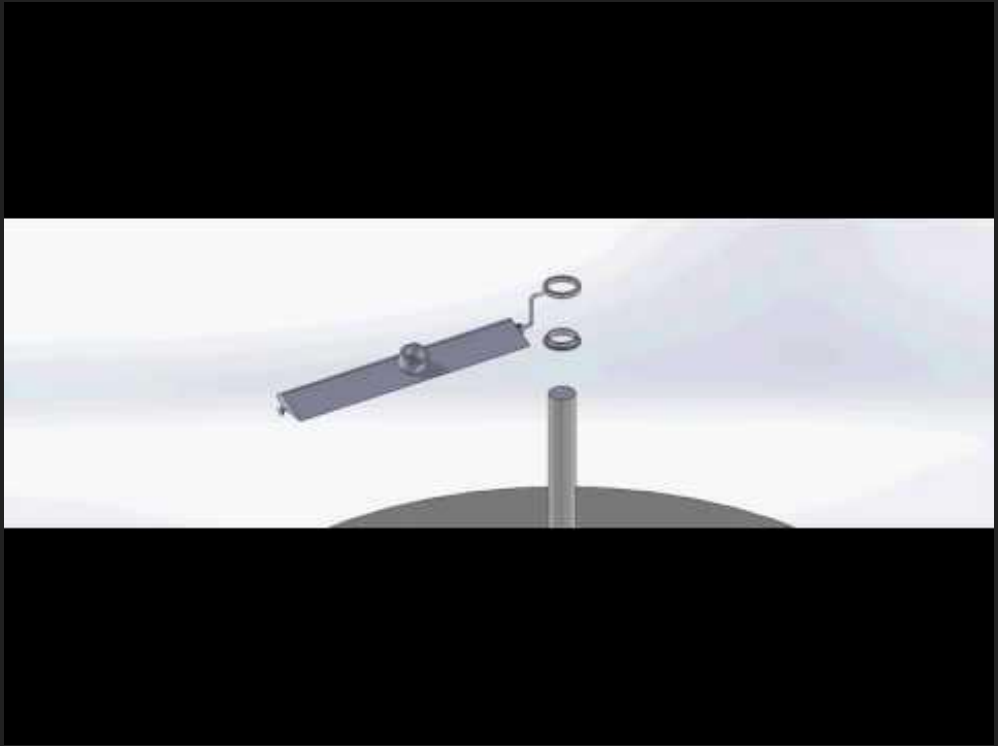
# Sweeping Suction Design







# Model Animation



# Slip Ring Concept

# Pros/Cons

## Pros

1. Complete removal with single armature rotation
2. Minimal moving parts
3. Simple design
4. Inexpensive
5. Low likelihood of

## Cons

1. Minimized suction force due to large suction slit
2. Inability to maneuver over and around obstacles
3. Lack of suction control
4. Possibility for clogging throughout system

# Options for Improvement

Con 1

- Increase exit diameter for increased flow rate
- Shorten armature and integrate uni-axial movement

Con 2

- Replace armature end wheel with single track
- Allow vertical motion of armature in order to maneuver over obstacles
- Implement axial suction at end of armature to clean between internal I-beam skeleton and walls

# Options for Improvement (Cont’d)

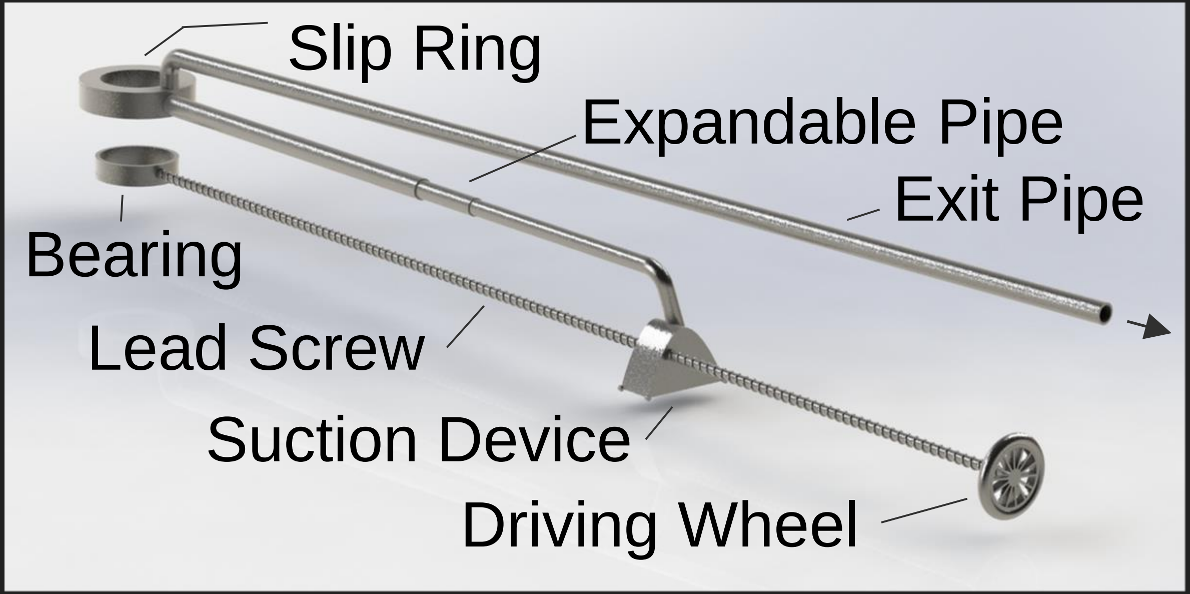
Con 3

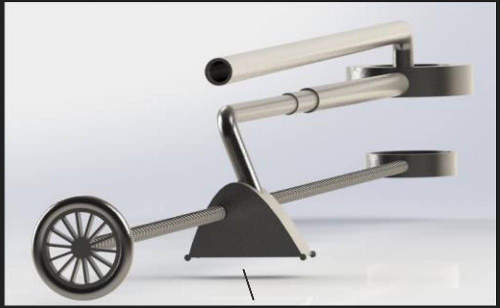
- Detailed analysis of fluid through slit (CFD)
- Implement 1-to-1 pipe-to-slit area ratio

Con 4

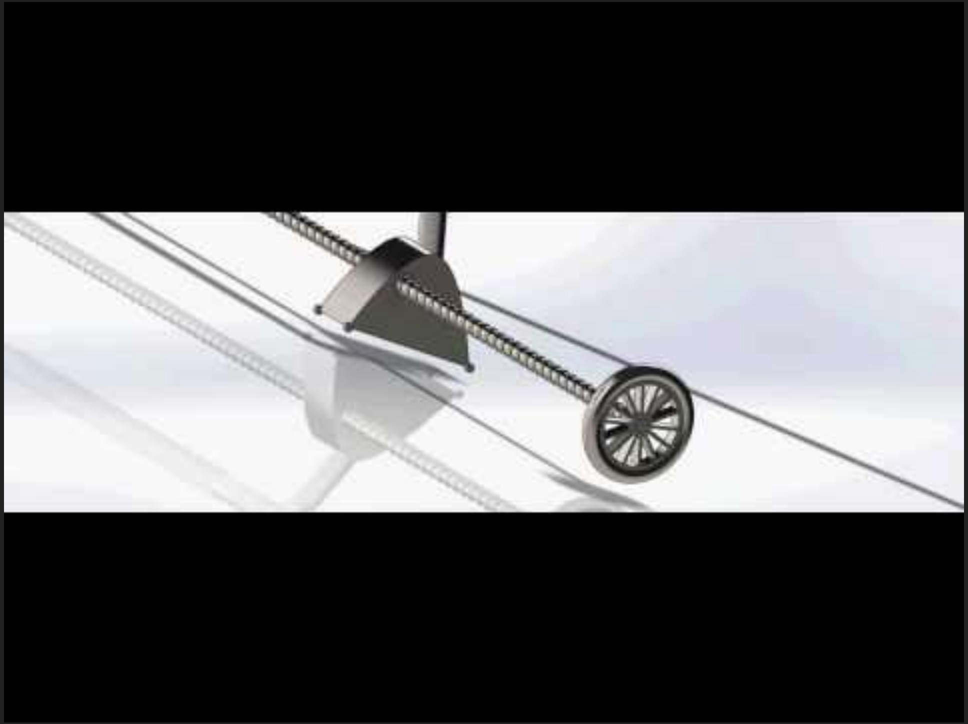
- Detailed analysis of fluid through system (CFD)
- Increase flow rate to minimize build up
- Minimize areas prone to flow separation
- Self cleaning system

# Lead Screw Design



# Lead Screw Animation



# Pros/Cons

## Pros

1. Can handle larger sediment buildups
2. Large, localized suction force
3. Potential to be very versatile
4. Not as prone to internal buildup and clogging

## Cons

1. Many mechanical parts
2. Expandable tube
3. Lengthy  tank cleaning duration
4. Inability to maneuver above and around obstacles
5. Heavy steel lead-screw

# Options for Improvement

Con 1

- Increase factor of safety
- Replace lead screw system with belt and pulley system
    - UI campus vending machines
- Concentrate on extreme simplification of every part

Con 2

- Integrate tube spool for flexible tubing
- Stretchy or expandable tubing

# Options for Improvement (Cont’d)

Con 3

- Utilize suction both forwards and backwards
- Optimize system for maximum suction head motion speed
- Lengthen suction device, increasing slit area

Con 4

- Replace wheel and lead-screw system with track and belt drive
- “...” rack and pinion drive
- Allow 90 degree rotation of suction head to clean walls

# Options for Improvement (Cont'd)

Con 5

- Track (snowmobile) and belt drive using lightweight system for armature support
  - Truss, I-beams, parallel support bars
- Replace track with rack and pinion using "..."
  - "..."

# Potential Problems

## Lack of Versatility

- Obstacles in tank
  - Pipes, beams, diffusers
- Tank floors aren’t all flat
  - Spherical, ribbed, conical, etc
- Need a center support beam for current design
- Sediment clogging or settling in system

# Computer Modeling

EES was used to estimate

- Volumetric Flow
- Outlet and Inlet Velocity
- Head Loss
- Scaling from Model and Full Size Tank
- System Curve

CFD will be used next semester for

# EES Key Equations

## Continuity Equation

$$A_1 v_1 = A_2 v_2$$

## Volume of Sediment

$$V = \pi r^2 h$$

## Energy Equation

$$\frac{P_1}{\gamma} + \frac{V_1^2}{2g} + z_1 + h_p = \frac{P_2}{\gamma} + \frac{V_2^2}{2g} + z_2 + h_L$$

# Testing Prototype 1

# Testing Flow Rate

1) Fill upper tank with water
2) Measure vertical head
3) Simultaneously start flow and timer
4) Fill bottom bucket to marked two gallon line
5) Record time and calculate volumetric flow rate in gpm

# Experimental Data

## Tested flow rates with first prototype

| Run | Head (ft) | Volume (gal) | Time (min) | Flow Rate (gpm) |
|---|---|---|---|---|
| 1 | 7 | 2 | 1.39 | 1.44 |
| 2 | 7 | 2 | 1.37 | 1.46 |
| 3 | 7 | 2 | 1.35 | 1.49 |
| 4 | 7 | 2 | 1.35 | 1.48 |
| 5 | 7 | 2 | 1.37 | 1.46 |

Average Flow Rate = 1.466 gpm

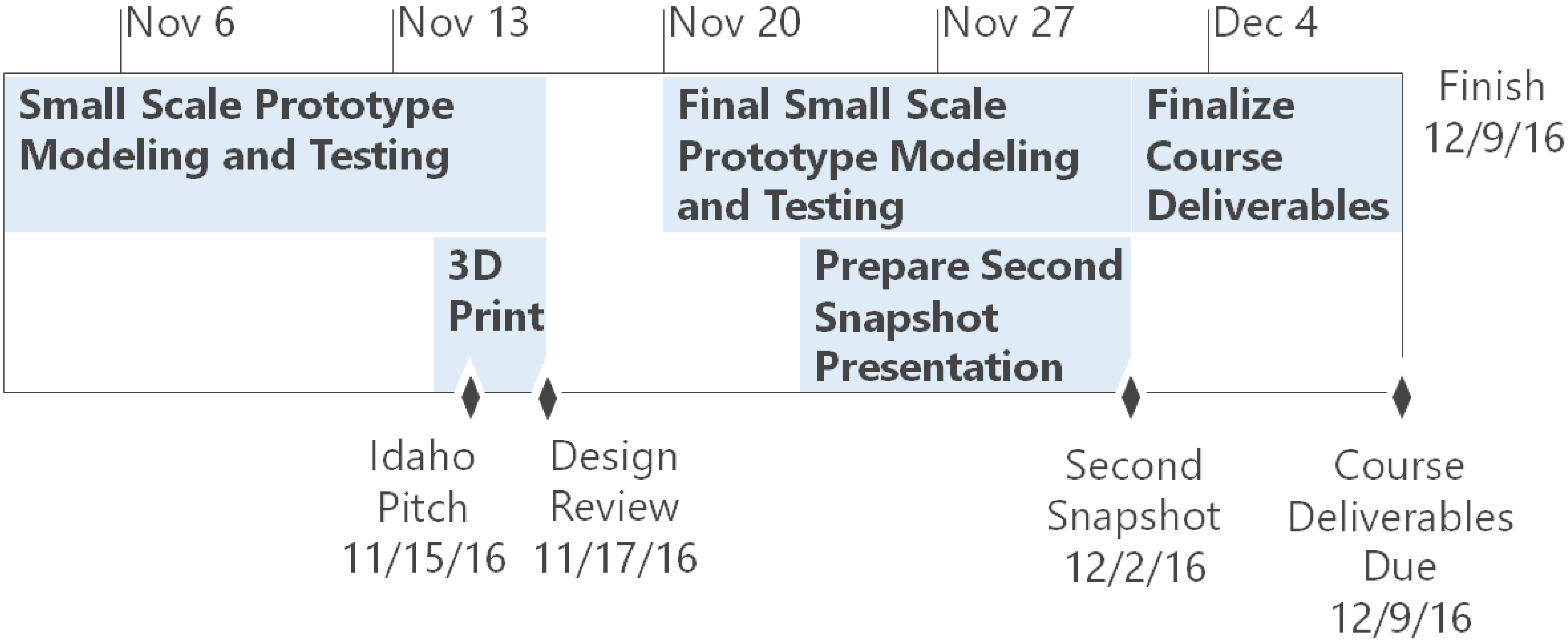
# Testing Inlet Velocity to Displace Sediment

1) Fill upper tank with water and flour
2) Let flour settle
3) Start gravity flow suction
4) Move vacuum head to flour to start sucking flour
5) Decrease outlet height until no flour is displaced

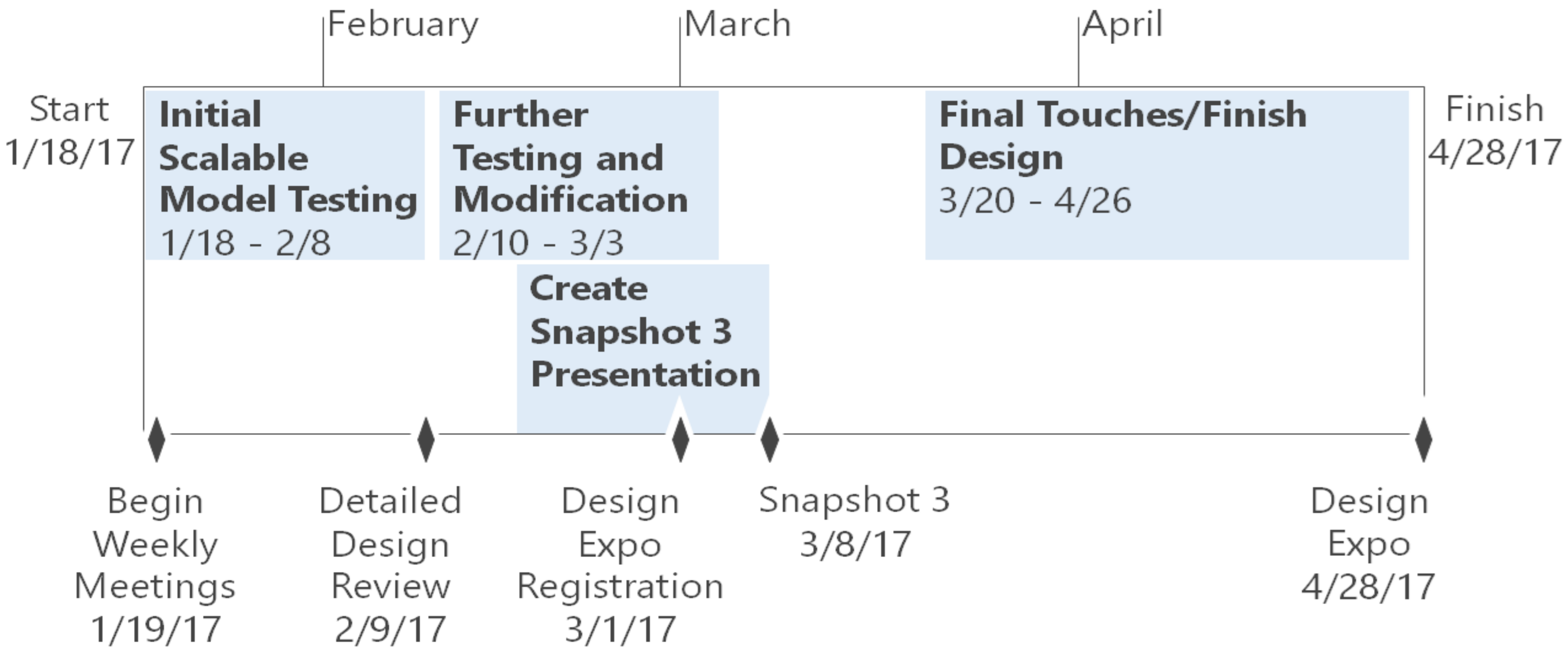
# Test Findings

- As long as there was any volumetric flow rate flour was displaced
- Flour moved very easily in water when moving with finger
- May need to consider a more dense surrogate sediment

# Ending Fall Semester Timeline



# Next Semester



# Questions?